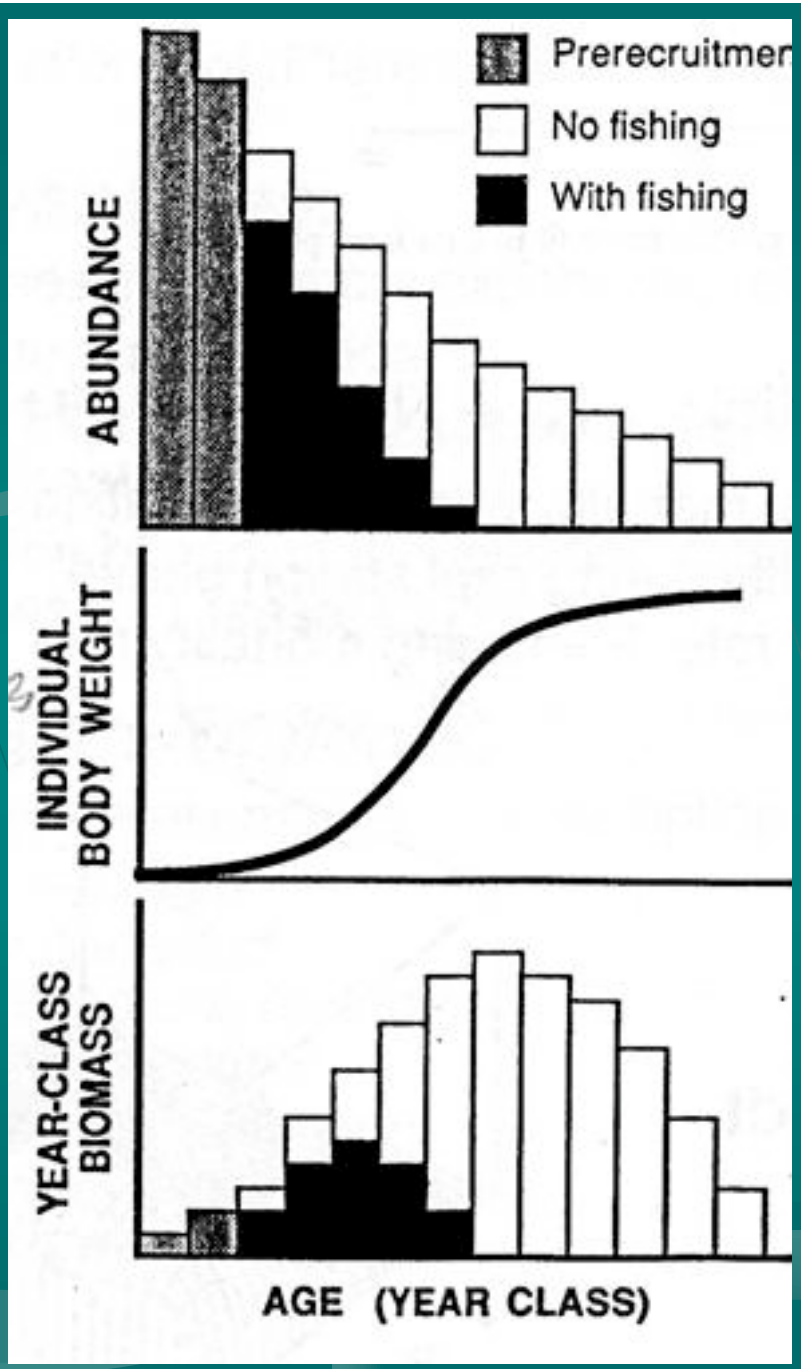
Fisheries Oceanography: Fisheries Management

OCN 621

Fisheries as Predation

- From a fisherman's perspective, natural mortality is "wasted."
- Fisheries compete with natural losses by catching fish before they are eaten or die of old age.
- Fishing changes the size and age structure of the stocks, thereby reducing the "resiliency" of stock to environmental fluctuations.



Fisheries Management Approaches

- Goals to Balance:
  - Socio-economic -- maximize “benefit” to society, i.e., optimize physical yield without jeopardizing ability of stock to reproduce
  - Biological -- protect genetic diversity, population integrity, habitat
  - Economic -- optimize economic gain; efficiency

Theory of Fisheries Management

- Unfished, “virgin” stock

- Fished stock

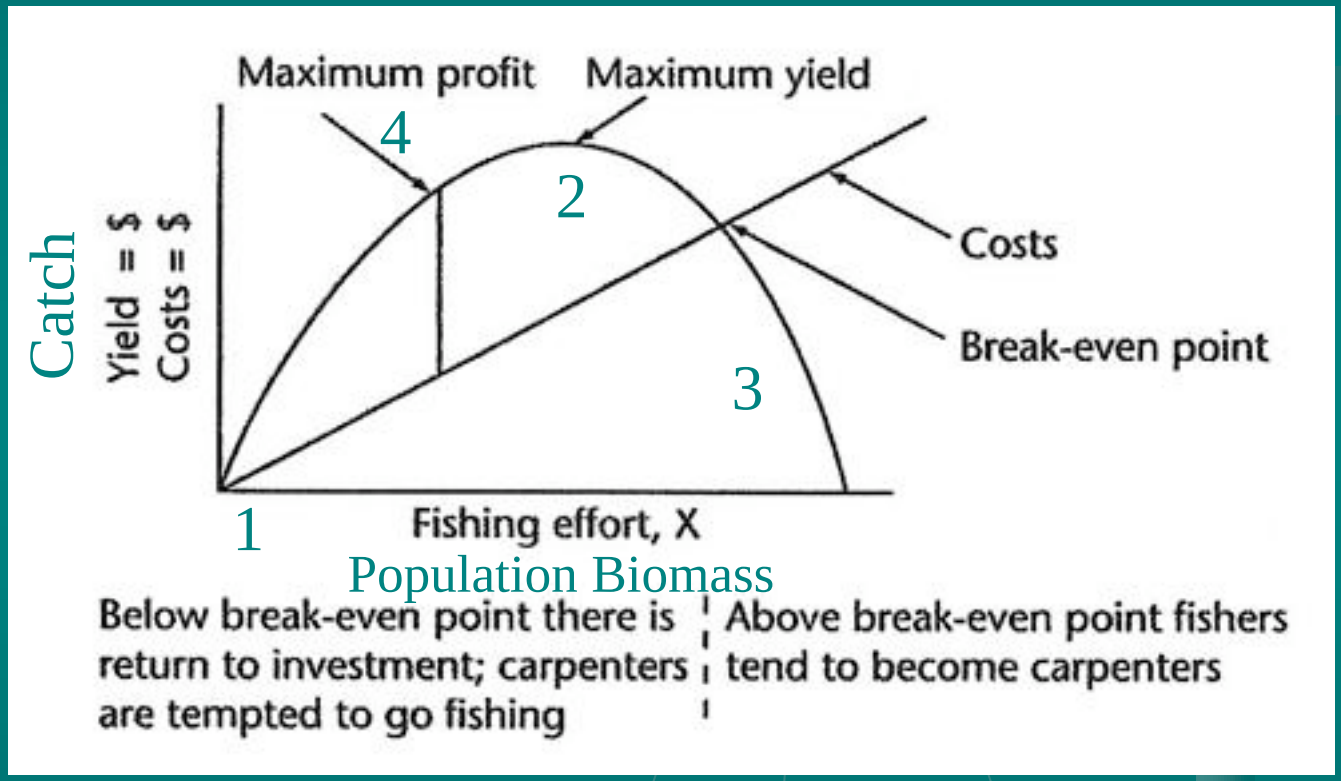
Compensating mechanisms for Fishing Mortality leading to lower Natural Mortality (Density-dependence):

-- growth increases (less competition for resources)

-- recruitment increases (less competition, more survivorship, less predation)

What is a suitable (sustainable) amount of Fishing Mortality?

MSY = Maximum Sustainable Yield



Zone 1: under-fished (catch good, cost low, profits high)
Zone 2: MSY (catch more, costs more, profit good)
Zone 3: over-fished (catch less, costs high, profit negative)
Zone 4: optimum yield (catch vs. cost best, max. profit)

CPUE

Catch Per Unit Effort

- Catch/Fishing Effort: really the only relationship we know well
- If this ratio is declining, we are over-fishing
- World CPUE in decline since 1980s
- Estimate that 45% of fisheries over-fished at present

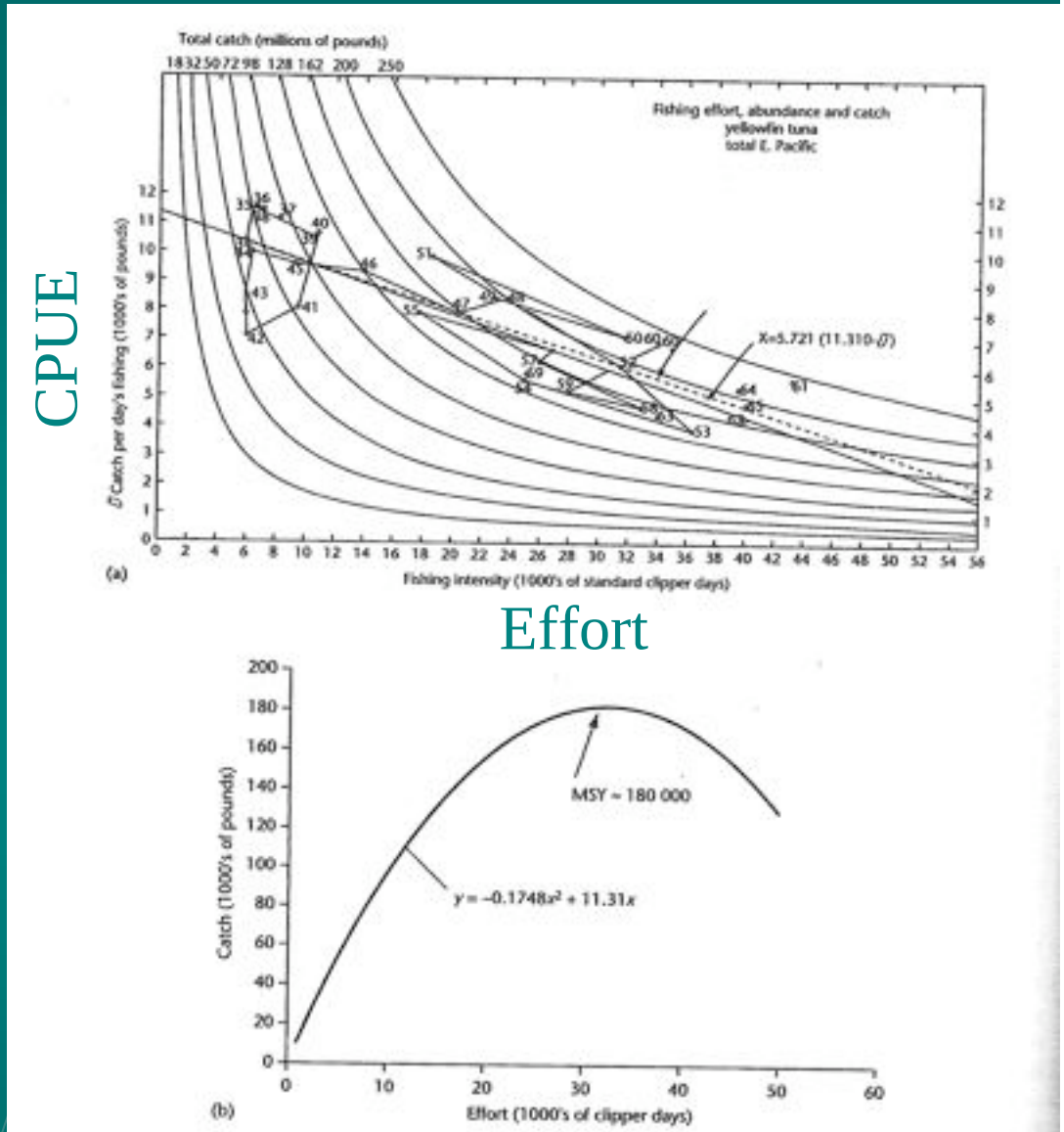


Fig. 15.7 (a) CPUE (catch per unit effort) for yellowfin tuna in the eastern tropical Pacific, 1934–1965. (b) Line is (a) converted to show catch vs. effort, a parabola. (a,b after Schaefer 1967.)

Miller 2004

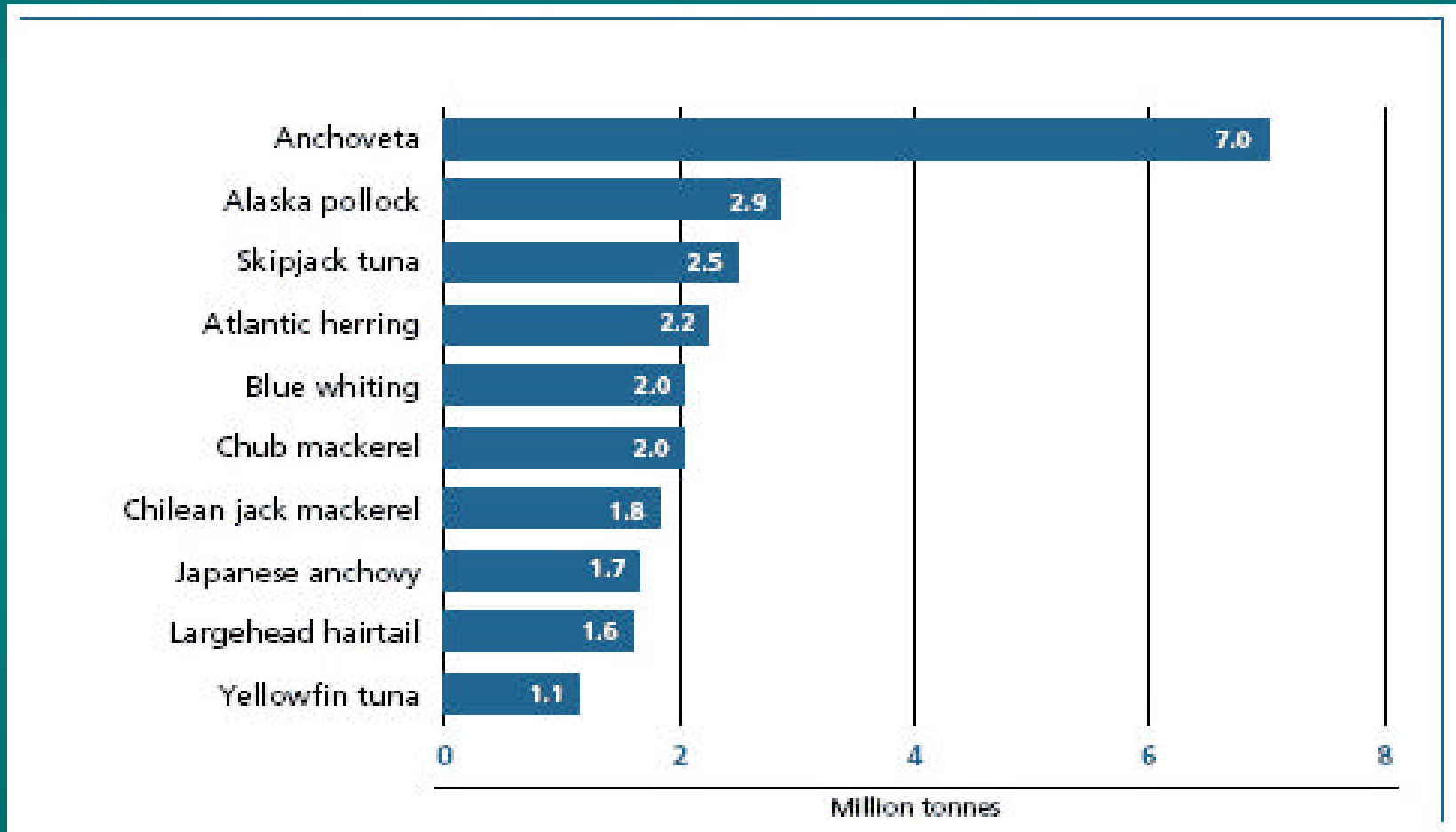
Single Species Management

Usual method, but, too narrowly focused, as fishing for one species can affect other exploited fish

- Discards/bycatch usually discarded dead
  - dead mammals, reptiles, etc. in gill nets
  - example: Shrimp trawling: 125 - 830% by catch excess over shrimp and bycatch is snapper

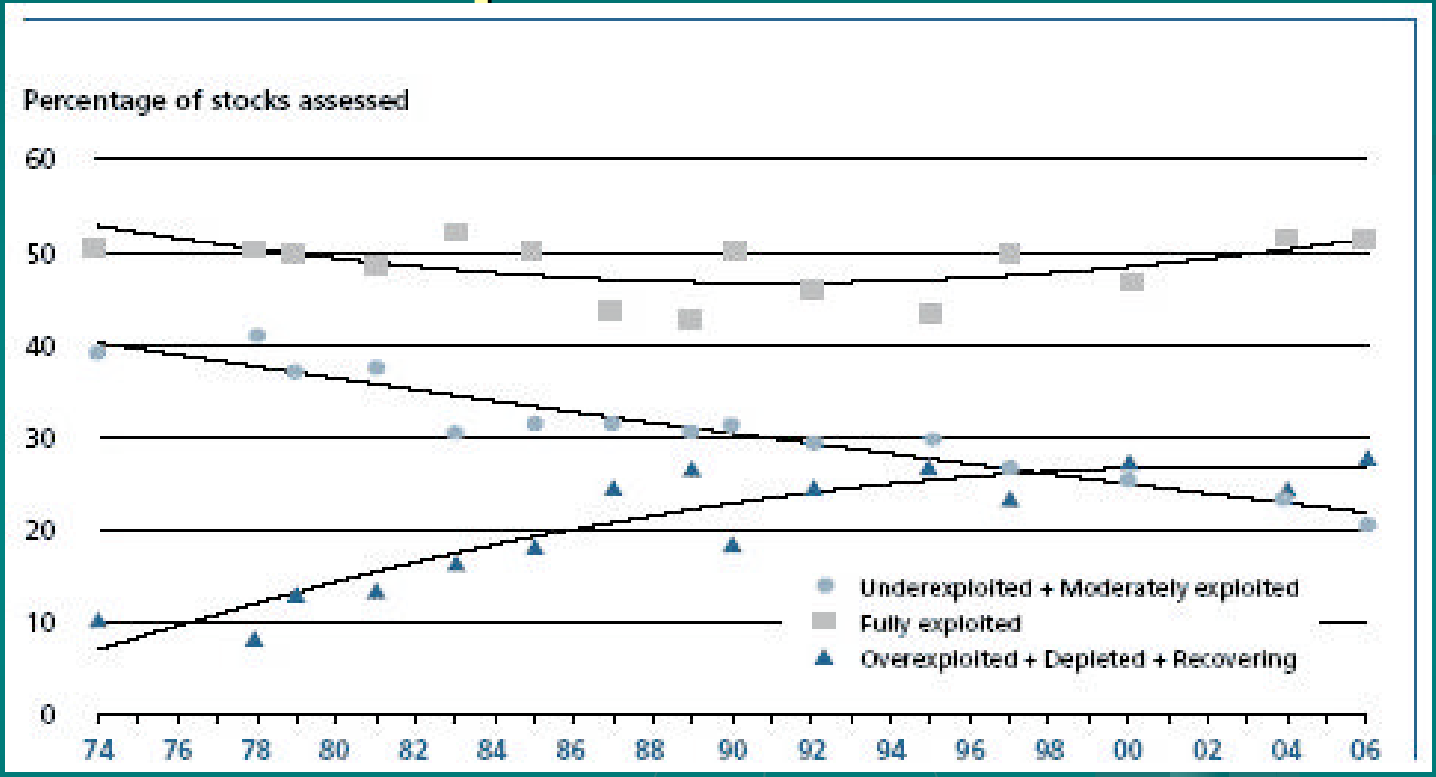
NOAA Photo library

Top 10 Fish of 2006 (30% of fisheries production)



Source: FAO Fisheries ***– The State of World Fisheries and Aquaculture, 2008 PART 1:World review of fisheries and aquaculture, p. 12***

Current state of world fisheries production



Source: FAO Fisheries ***– The State of World Fisheries and Aquaculture, 2008***
PART 1:World review of fisheries and aquaculture, p. 33

~50% of world stocks fully exploited

Previously over-exploited, depleted or recovering stocks have been stable for 10-15 years

Commercially harvested marine fish

- Anchovy, herring and sardines: all small pelagic fish, represent by far the largest fisheries in the world
- Live in highly productive areas (upwelling regions & off Japan & Argentina)
- Unstable populations (time scale of 10 - 30 yrs)

Unstable populations: collapse of fisheries is a function of over-fishing & natural environmental change

Peruvian anchoveta: #1
Engraulis ringens

- Vital statistics
  - Max size: 20 cm
  - Max reported age: 3 years; time to maturity: 1 year
  - Depth range found: 3 - 80 m
  - Distribution
  - Ecosystem role: eats phytoplankton & zooplankton, preyed upon by man and seabirds
  - Spawn near shore; Behavior enabling high success of fishery? Schooling

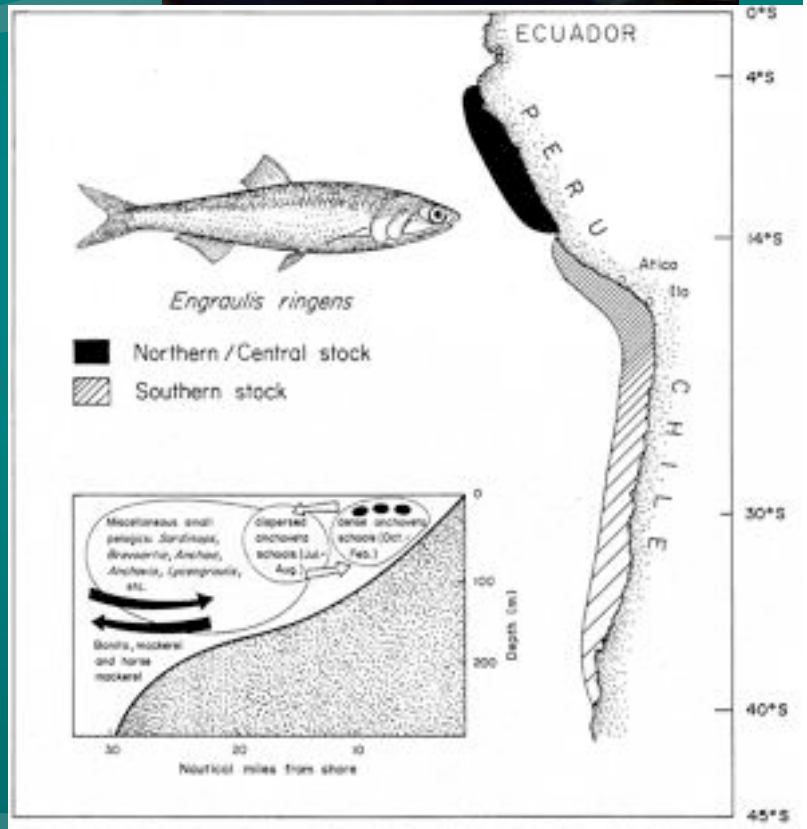


Fig. 1. Distribution of anchoveta stocks along the Eastern Coast of South America. Based on FAO (1981), Jordan (1971), Chirichigno (1974), Brandhorst (1963) and IMARPE (1975).

History

mid-1950 Fishery begins and rapidly expands (fish meal for livestock)

1964 Catch = 8.7 MMT (17% of world catch); Schaefer (FAO study) estimates MSY at 9.5 MMT, but guano birds and other predators took 2 MMT leaving 7.5 MMT for man

1965 El Nino - low reproductive success, schools dispersed, bird predators gone (Cormorants)

1970 Harvest 12.5 MMT; 50% greater than MSY; fishing efficient, ~95% of fish caught before reaching reproductive age (*overcapitalization*)

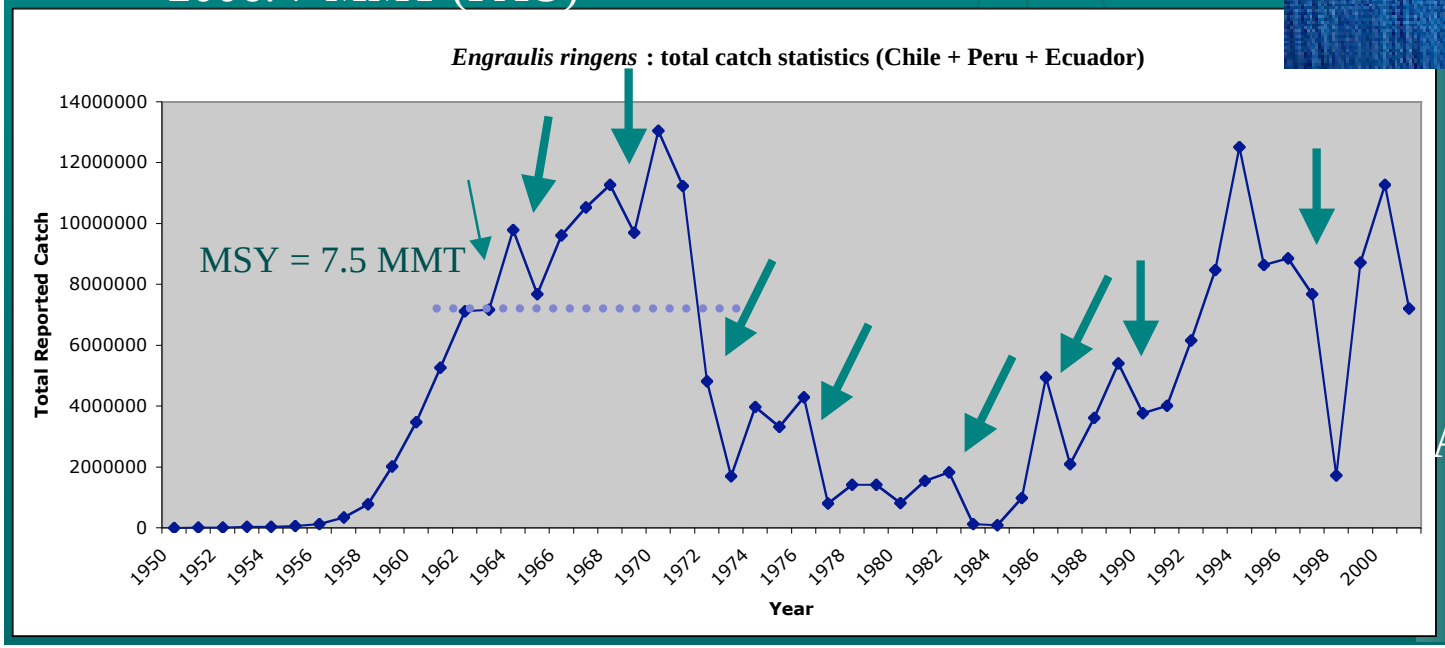
1971-2 Bad recruitment years (El Nino, too): collapse of fishery

1986-96 Recovery

1997-98 El Nino collapse, recovering now

2004: 10.7 MMT (FAO)

2006: 7 MMT (FAO)

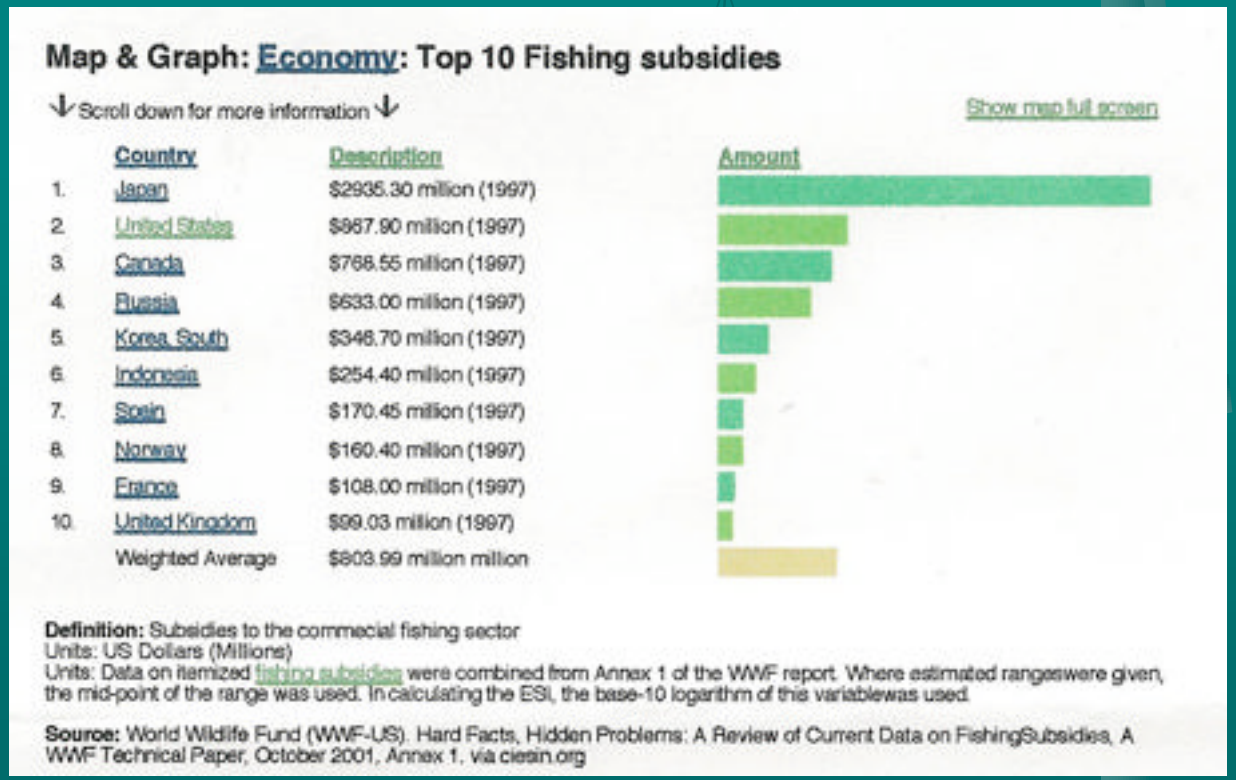


Arrows = El Niño years

Overcapitalization

- When fishing is good, more boats are built, people employed
- When yield declines, it is hard to cut back
- Subsidies are paid to fisherman
- Fishing continues, even though not commercially viable
- Exacerbates over-fishing problems, but not a surprising consequence of economic pressures

http://www.nationmaster.com



Map & Graph: Economy: Top 10 Fishing subsidies

↓ Scroll down for more information ↓ Show map full screen

	Country	Description	Amount
1.	Japan	$2935.30 million (1997)	
2.	United States	$987.90 million (1997)	
3.	Canada	$768.55 million (1997)	
4.	Russia	$633.00 million (1997)	
5.	Korea, South	$346.70 million (1997)	
6.	Indonesia	$254.40 million (1997)	
7.	Spain	$170.45 million (1997)	
8.	Norway	$160.40 million (1997)	
9.	France	$108.00 million (1997)	
10.	United Kingdom	$99.03 million (1997)	
	Weighted Average	$803.99 million million	

Definition: Subsidies to the commecial fishing sector
Units: US Dollars (Millions)
Units: Data on itemized fishing subsidies were combined from Annex 1 of the WWF report. Where estimated rangeswere given, the mid-point of the range was used. In calculating the ESI, the base-10 logarithm of this variablewas used.

Source: World Wildlife Fund (WWF-US). Hard Facts, Hidden Problems: A Review of Current Data on FishingSubsidies, A WWF Technical Paper, October 2001, Annex 1, via ciesin.org

Peruvian Anchovy

- Effects of El Niño
  - anchovy feeds on phytoplankton/zooplankton
  - during El Nino, no upwelling, fewer phytoplankton, fewer zooplankton, fewer fish
- Other ecosystem effects of fishing
  - Depleting anchovy stocks results in reduced populations of fish-eating sea birds

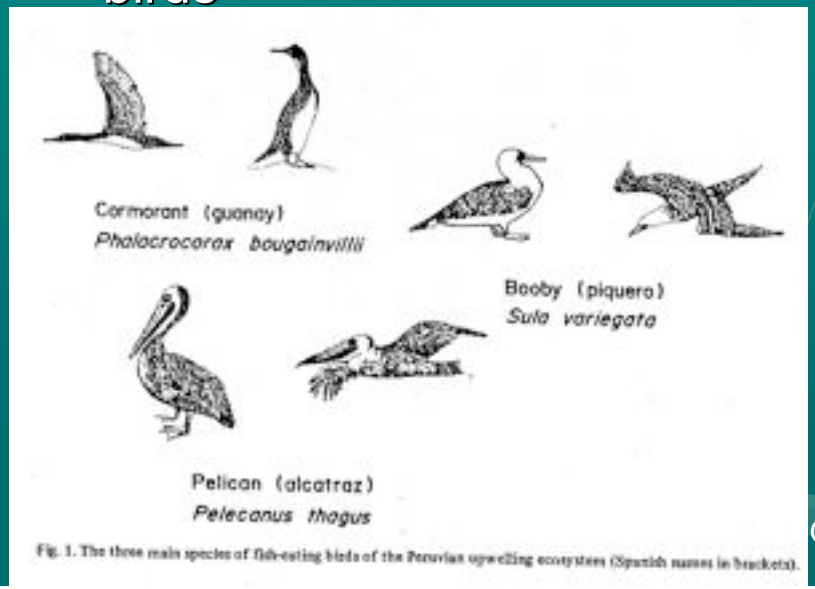


Fig. 1. The three main species of fish-eating birds of the Peruvian upwelling ecosystem (Spanish names in brackets).

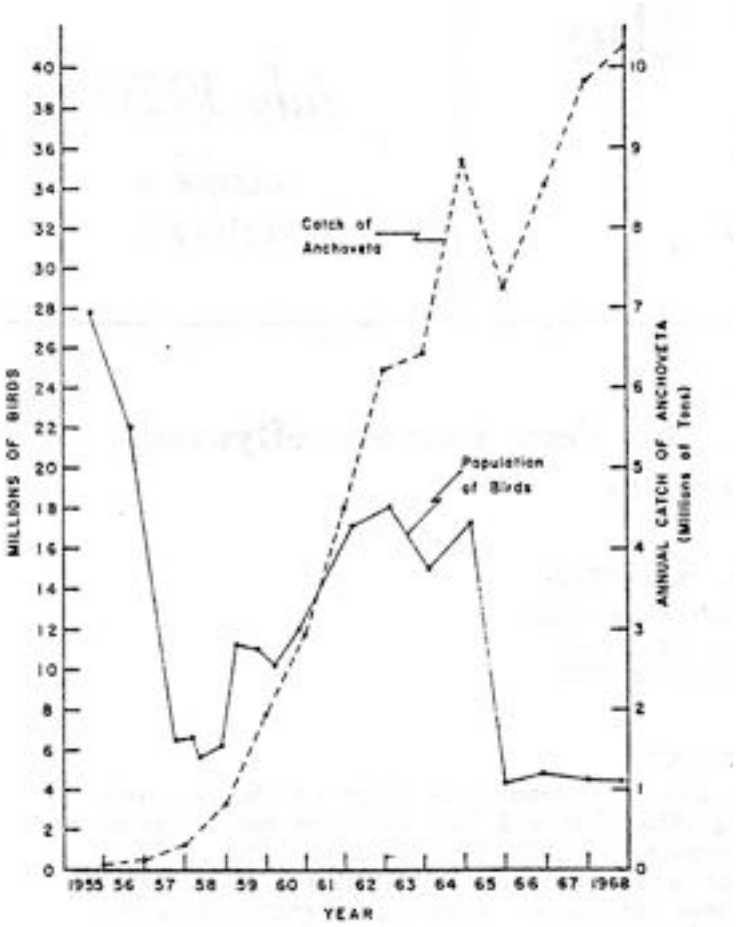
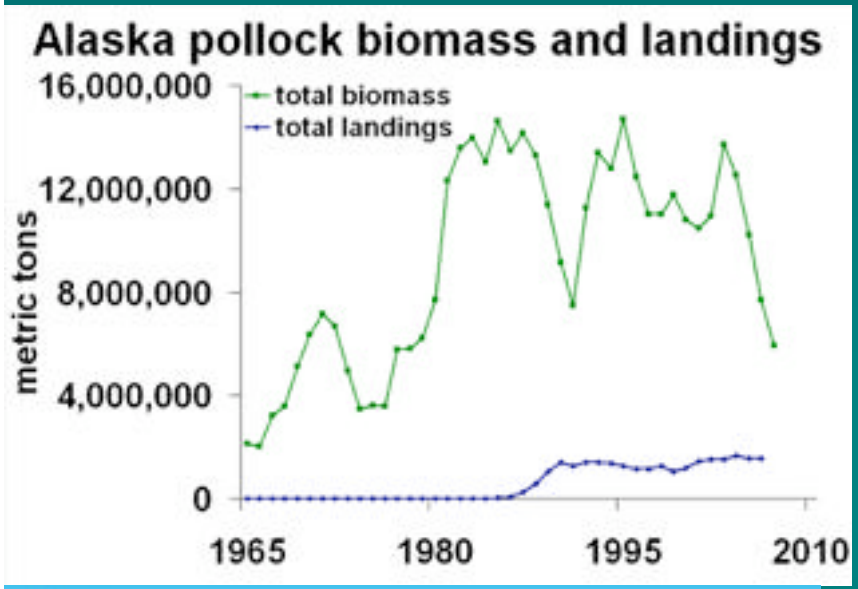
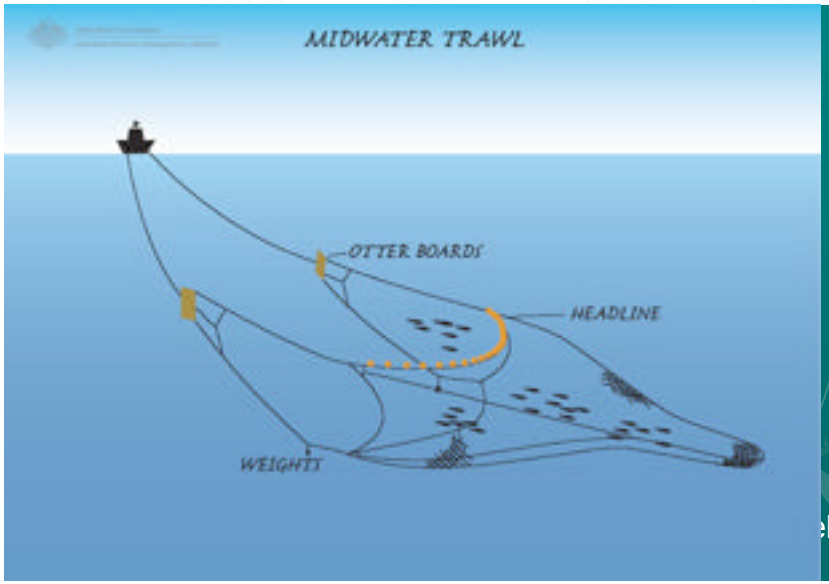


FIGURE 1.—Commercial catch of anchoveta by calendar years, and population of guano birds from censuses at indicated dates.

Schaefer 1970

Alaska Pollock
Theragra chalcogramma

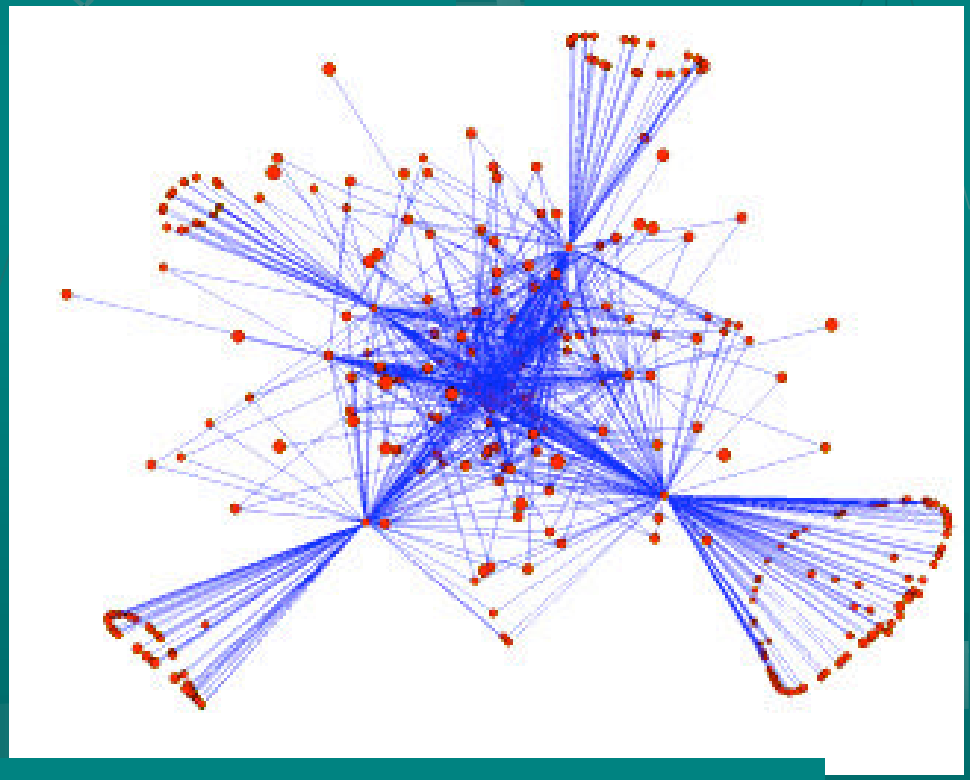




- max size/age: 91 cm, 15 years, age at 1st maturity: 3 - 5.5 yr
- benthopelagic, brackish/marine waters, usually found from ~300 - 1000 m depth
- DVM, feeds on fish and crustaceans (esp. krill), TL = 2.8+
- Prey for Stellar Sea Lion (Alaska) & other marine mammals, seabirds, bigger fish
- Well managed fishery, use midwater trawl nets with little by-catch

Alaska Pollock Fishery

- Currently well managed, but not managed as a multispecies fishery
- Efforts are going into ecosystem modeling, including physical forcing, to better predict all fisheries in region



GOA Ecosystem

Each species is a node (dots) and each predator-prey interaction is a link (line).

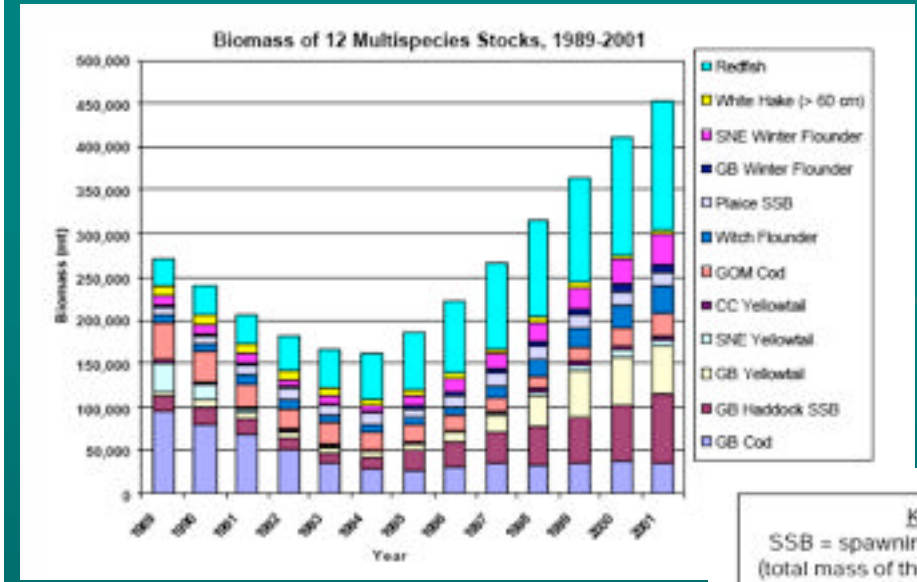
Four hubs are cod, pollock, halibut and arrowtooth flounder.

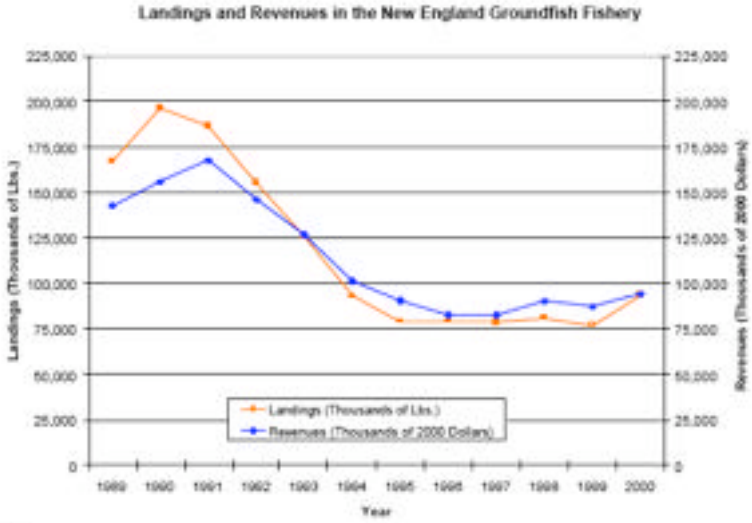
S. Gaichas, NOAA, www.afsc.noaa.gov

Multispecies Management

Example: New England Groundfish Fisheries

- 15 species managed
- implemented in 1986, but did not include catch or fishing effort restrictions
- 1994: Amended management plan to address these problems





Key
SSB = spawning stock biomass (total mass of the stock capable of spawning)
GB = Georges Bank
GOM = Gulf of Maine
SNE = Southern New England
CC = Cape Cod

www.nefmc.org

Application to Anchovy Fishery

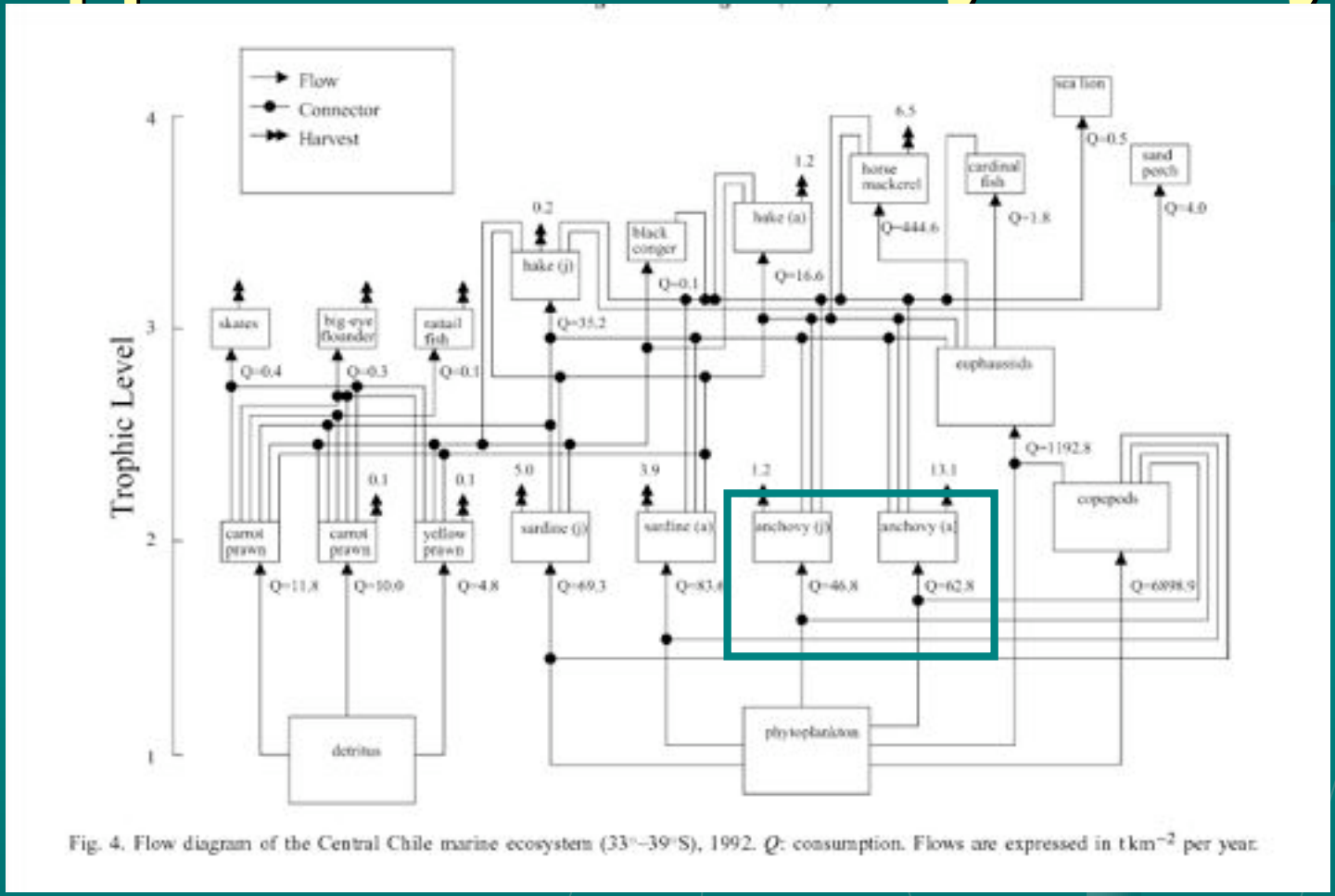


Fig. 4. Flow diagram of the Central Chile marine ecosystem (33°–39°S), 1992. *Q*: consumption. Flows are expressed in $t\,km^{-2}$ per year.

Niera et al. 2004. Comparative analysis of trophic structure of commercial fishery species off Central Chile in 1992 and 1998. Ecol. Model. 172:233-248

Global Fish Catch

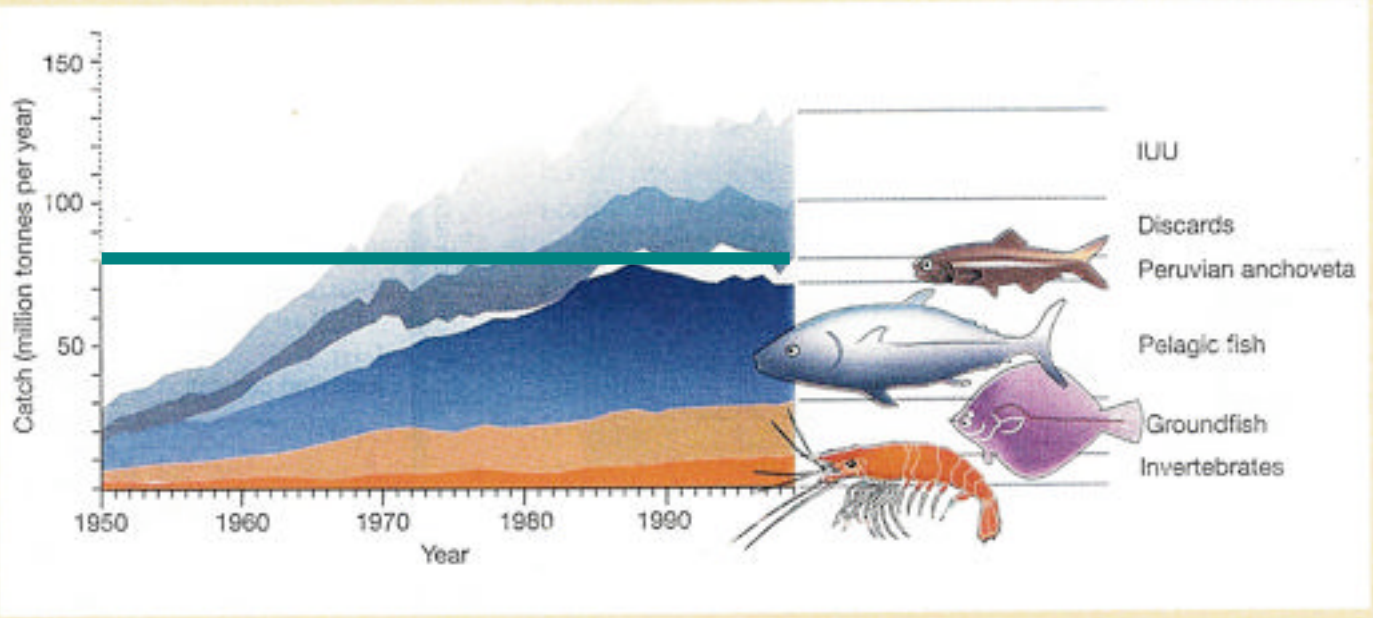


Figure 1 Estimated global fish landings 1950–1999. Figures for invertebrates, groundfish, pelagic fish and Peruvian anchoveta are from FAO catch statistics, with adjustment for over-reporting from China[26]. Fish caught but then discarded were not included in the FAO landings; data relate to the early 1990s[63] were made proportional to the FAO landings for other periods. Other illegal, unreported or unregulated (IUU) catches[65] were estimated by identifying, for each 5-year block, the dominant jurisdiction and gear use (and hence incentive for IUU)[64]; reported catches were then raised by the percentage of IUU in major fisheries for each 5-year block. The resulting estimates of IUU are very tentative (note dotted *y*-axis), and we consider that complementing landings statistics with more reliable estimates of discards and IUU is crucial for a transition to ecosystem-based management.

Pauly et al. 2002

Global Catch

"Corrected" global catch: ~80 MMT

How do they gather the data?

Individual countries tell the FAO how much was caught by their fishermen

Usual Problem: under-reporting

Apparent Problem with China: over-reporting

Particularly misleading for overall picture of fisheries health, as China's catch is a high proportion of the total world catch

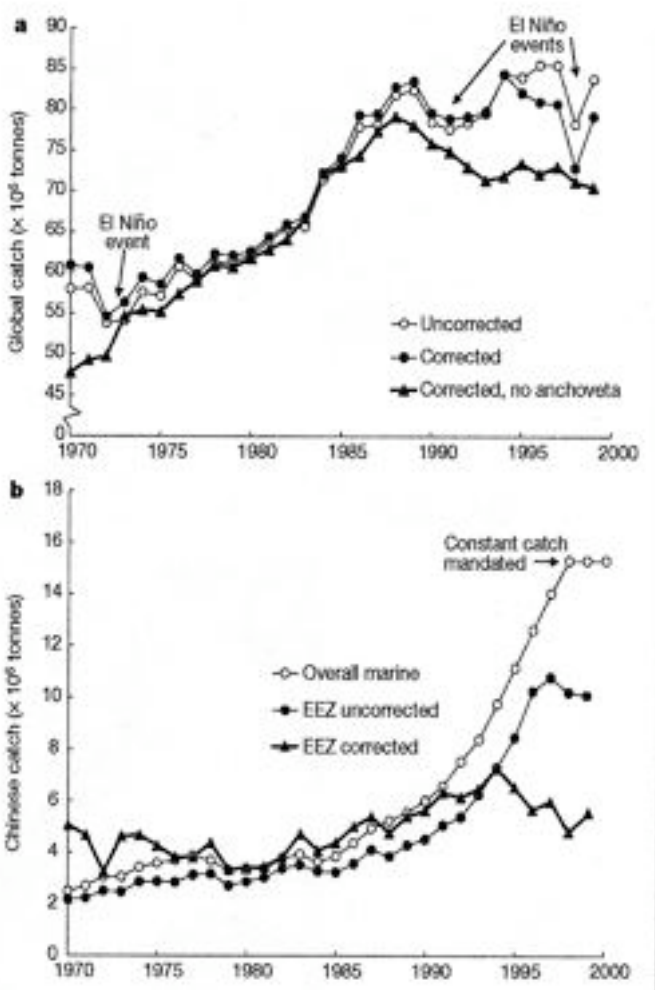


Figure 1 Time series of global and Chinese marine fisheries catches (1950 to present). **a**, Global reported catch, with and without the highly variable Peruvian anchoveta. Uncorrected figures are from FAO (ref. 3); corrected values were obtained by replacing FAO figures by estimates from **b**. The response to the 1982–83 El Niño/Southern Oscillation (ENSO) is not visible as anchoveta biomass levels, and hence catches were still very low from the effect of the previous ENSO in 1972 (ref. 4). **b**, Reported Chinese catches (from China's exclusive economic zone (EEZ) and distant water fisheries) increased exponentially from the mid-1980s to 1998, when the 'zero-growth policy' was introduced. The corrected values for the Chinese EEZ were estimated from the general linear model described in the Methods section.

Watson & Pauly 2001

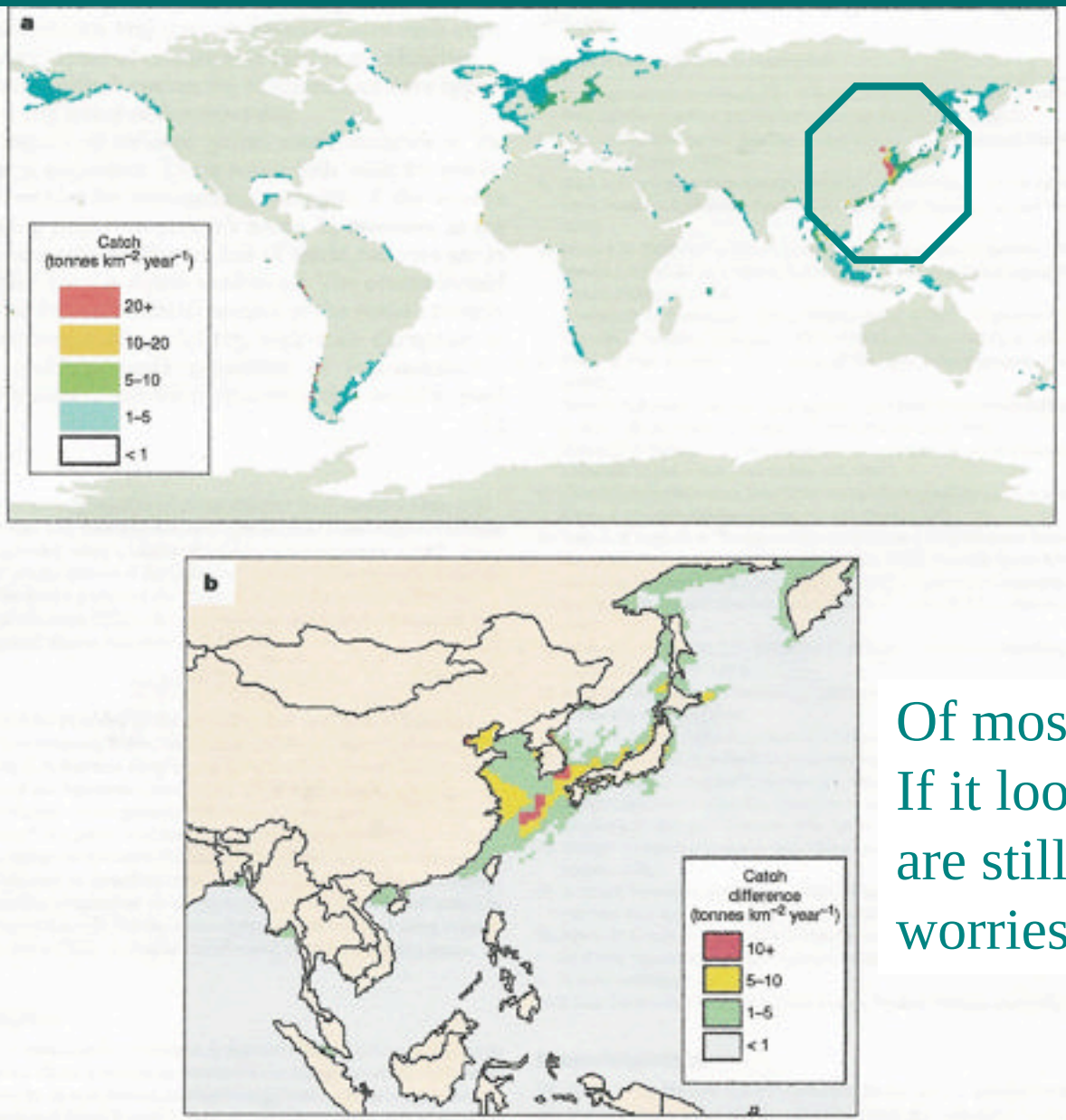
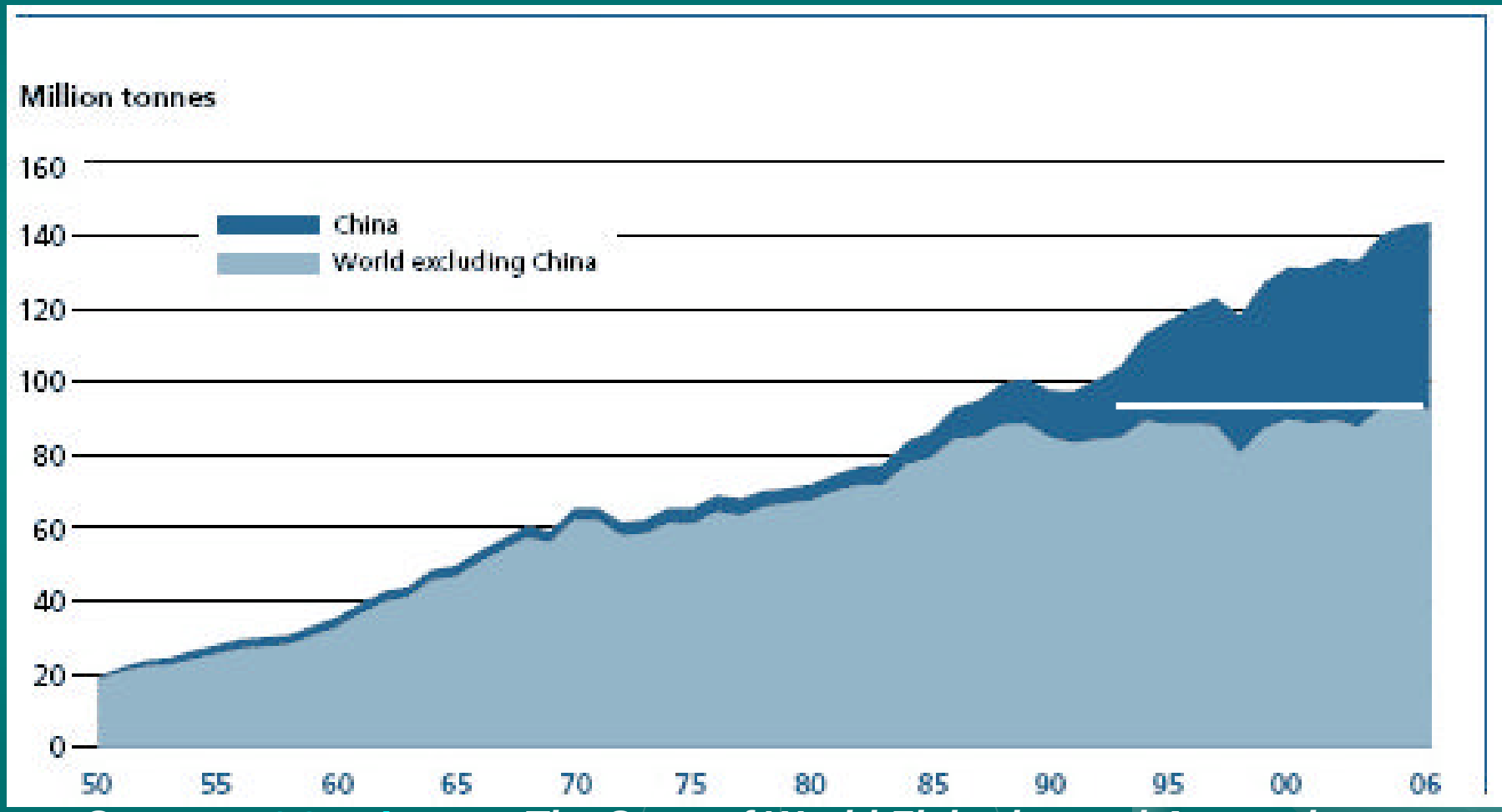


Figure 2 Maps used to correct Chinese marine fisheries catch in Fig. 1b. **a**, Map of global catches reported by FAO for 1998, generated by the rule-based algorithm described in the Methods section. We note the anomalously high values along the Chinese coast, comparable in intensity (not area covered) to the extremely productive Peruvian upwelling system. **b**, Map of differences in southeast and northeast Asia between the catches reported in **a** and those predicted by the model described in the Methods section.

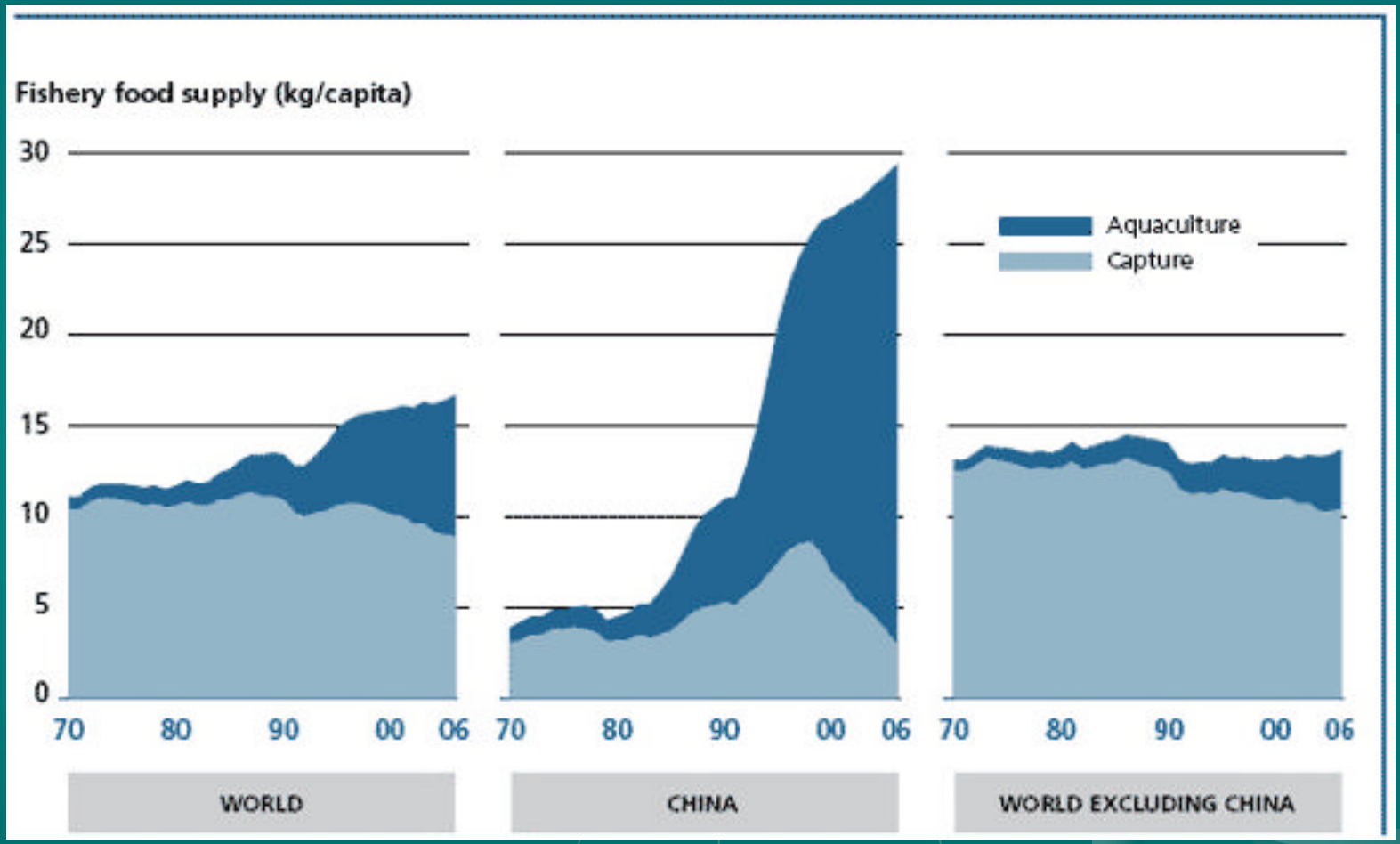
Of most concern:
If it looks like catches are still rising, no one worries...

Most recent data (released March 2, 2009): World Capture and Aquaculture Production



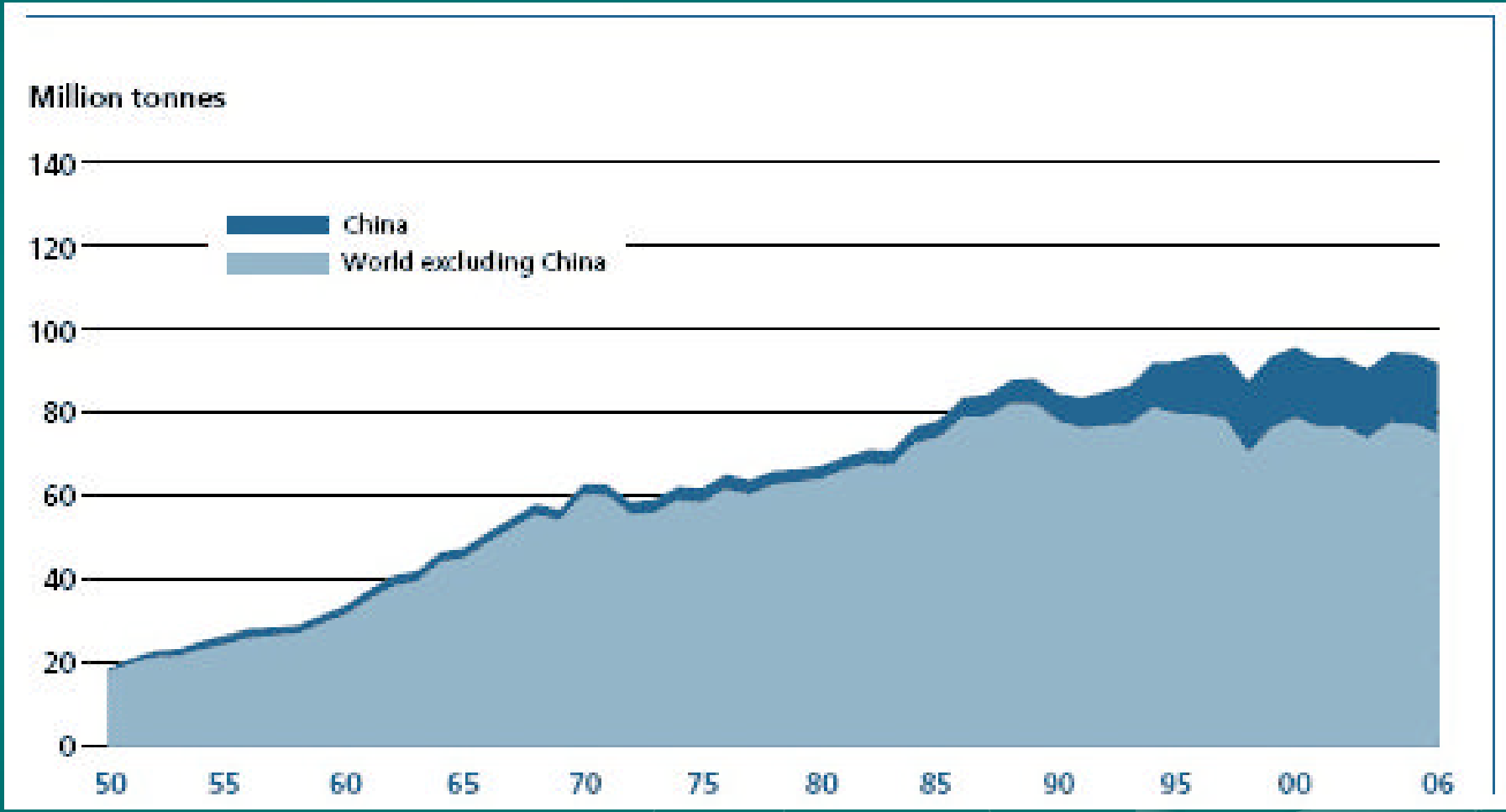
Source: FAO Fisheries ***– The State of World Fisheries and Aquaculture, 2008 PART 1:World review of fisheries and aquaculture, p. 4***

Aquaculture increasingly important...



Source: FAO Fisheries – The State of World Fisheries and Aquaculture, 2008
PART 1: World review of fisheries and aquaculture, p. 63

World Capture Fisheries Production



Source: FAO Fisheries ***– The State of World Fisheries and Aquaculture, 2008 PART 1:World review of fisheries and aquaculture, p. 6***

Global MSY

- Best estimate for global MSY = 100 - 135 MMT (all species, all oceans)
- Most recent compilation of world fisheries:

  92 MMT (Present Harvest)

  + Discards (by-catch), ~30% of total catch

  + IUU (Illegal, unreported or unregulated catch),

  All together, ~130 MMT

  - So, Global MSY reached already

Aquacultured Fish on the rise, however...

- Because top, or higher, trophic levels vanishing due to over-fishing, fishermen are exploiting lower trophic levels

- Note that dip in marine curve in 60's was due to extremely large catches of Peruvian anchovetta with low trophic level of 2.2 (TL = 2 is that of primary herbivores)

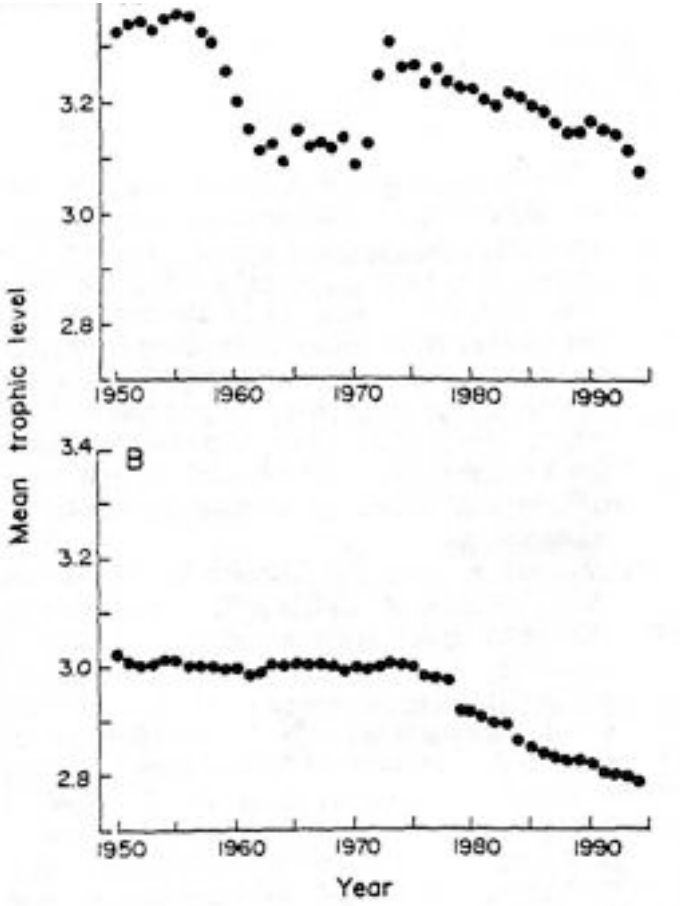


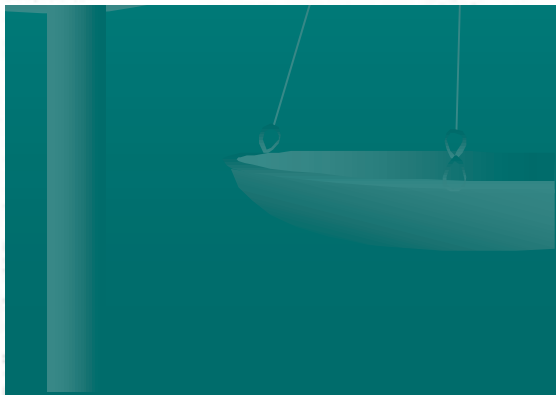
Fig. 1. Global trends of mean trophic level of fisheries landings, 1950 to 1994. (**A**) Marine areas; (**B**) inland areas.

1998

Fishing Down Marine Food Webs

Daniel Pauly,* Villy Christensen, Johanne Dalsgaard
Rainer Froese, Francisco Torres Jr.

The mean trophic level of the species groups reported in Food and Agricultural Organization global fisheries statistics declined from 1950 to 1994. This reflects a gradual transition in landings from long-lived, high trophic level, piscivorous bottom fish toward short-lived, low trophic level invertebrates and planktivorous pelagic fish. This effect, also found to be occurring in inland fisheries, is most pronounced in the Northern Hemisphere. Fishing down food webs (that is, at lower trophic levels) leads at first to increasing catches, then to a phase transition associated with stagnating or declining catches. These results indicate that present exploitation patterns are unsustainable.



Fishing down the food web

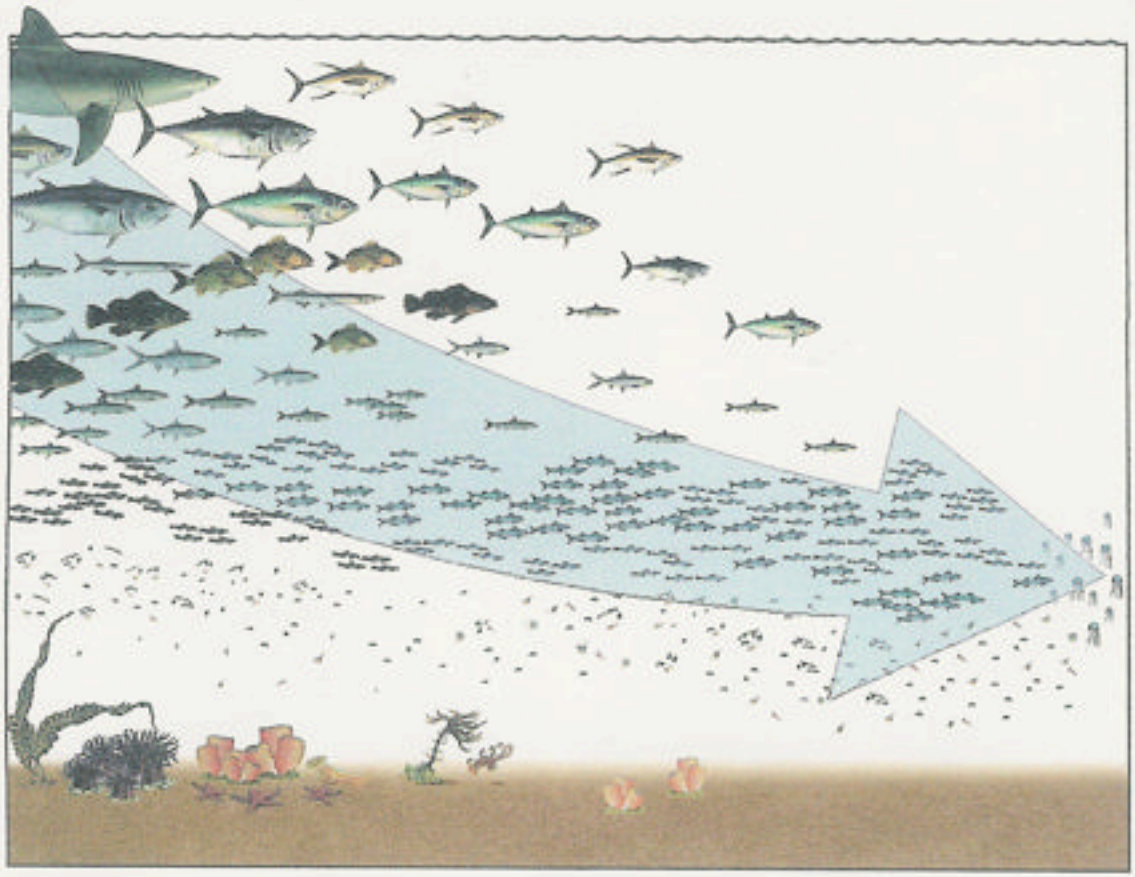


FIGURE 17. FISHING DOWN: WHAT IT ACTUALLY MEANS.
Fishing down marine food webs means that the fisheries (blue arrow), having at first removed the larger fishes at the top of various food chains, must target fishes lower and lower down, and end up targeting very small fishes and plankton, including jellyfish.

Pauly & Maclean 2003

One step in the right direction: Marine Protected Areas (MPA)

- Can “seed” fished areas
- Success dependant upon mobility of fish and size of MPA
- Wouldn’t help wide-roaming fish like tuna or other pelagic fish, but would help coastal-based fisheries

(unless they stop at “oases” in the open ocean and these are included)

- Also preserves habitat in case of destructive fishing (i.e., trawling which destroys bottom populations)
- Currently , 1300 marine reserves globally, but only 0.01% of world’s ocean areas are closed to fishing: need to have significantly more protection to make a global difference

http://www.fishbase.org

http://www.fishonline.org/

http://www.mbayaq.org/cr/cr_seafoodwatch

blueocean.org & edf.org

Pocket Good Fish Guide 2006

A quick reference to buying 'eco-friendly' fish

MCS Marine Conservation Society

www.fishonline.org